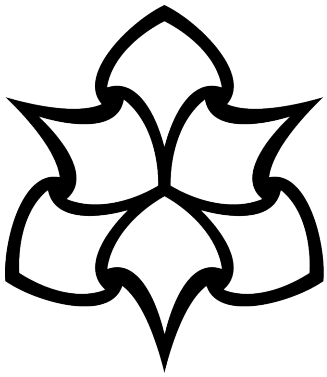

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Comparison of short-term effects of mobilization with movement and Kinesiotaping on pain, function and balance in patellofemoral pain

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ABSTRACT

Objective: The aim of this study was to compare the short-term effects of Mobilization with movement (MWM) and Kinesiotaping (KT) on patients with patellofemoral pain (PFP) respect to pain, function and balance.

Methods: Thirty-five female patients diagnosed with unilateral PFP were assigned into 2 groups. The first group (n = 18) received two techniques of MWM intervention (Straight Leg-Raise with Traction and Tibial Gliding) while KT was applied to the other group (n = 17). Both groups received 4 sessions of treatment twice a week for a period of 2 weeks with a 6-week-home exercise program. Pain severity, knee range of motion, hamstring flexibility, and physical performance (10-step stair climbing test, timed up and go test), Kujala Patellofemoral Pain Scoring and Y-Balance test were assessed. These outcomes were evaluated before the treatment, 45 min after the initial treatment, at the end of the 4-session-treatment during 2-week period and 6 weeks later in both groups.

Results: Both treatment groups had statistically significant improvements on pain, function and balance ($p < 0.05$). Pain at rest ($p = 0.008$) and the hamstring muscle flexibility ($p = 0.027$) were demonstrated significant improvements in favor of MWM group.

Conclusions: Our results demonstrated similar results for both treatment techniques in terms of pain, function and balance. The MWM technique with exercise had a short-term favorable effect on pain at rest and hamstring muscle flexibility than the KT technique with exercise in patients with PFP.

Level of evidence: Level I, therapeutic study.

Introduction

Patellofemoral Pain (PFP), also known as the anterior knee pain, is one of the most common musculoskeletal disorders. Women are two times susceptible to PFP than men and it comprises 13–18% of knee problems in females 18–35 years old.[1–3] The symptoms are usually in the form of permeating pain that starts from the anterior part of the knee, and the pain increases during the activities, such as prolonged sitting, stair climbing or descending, kneeling and squatting.[4–8]

In the treatment of PFP, conservative treatment methods are preferred prior to surgical ones.[9–11] Conservative treatment involves a multimodel physiotherapy approach including patient education, activity modification, neuromuscular electric stimulation on quadriceps, therapeutic ultrasound, biofeedback, exercises for enhancing the activity of Vastus Medialis Obliquus (VMO) muscle, lower extremity-strengthening exercises, proximal stabilization, stretching exercises on tight structures, bracings, foot orthoses, manual therapy and taping techniques.[9,11–13]

In recent years, one of the increasingly widespreading practices in PFP treatment is the Kinesiotaping (KT). There have been studies regarding the fact that this technique alleviates pain and edema by enhancing circulation, and that it improves the walking pattern as well as healing the muscle strength and function.[14–20] One of the current treatment methods used in musculoskeletal problems is

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the concept called Mobilization with Movement (MWM) approach which is a current and pain-free manual method of treatment that involves gliding performed by the physiotherapist, along with an active movement in the painful joint.[21,22] This method was shown to have alleviated the pain in musculoskeletal problems and to have improved the functioning, as well.[23–30] There is no study in which MWM method was used and in which the effects of it was shown and compared with KT has been found so far with respect to the treatment of PFP.

The main purpose of this clinical study was to compare the short-term effects of MWM and KT interventions in addition with the exercise therapy in terms of pain, function and balance in patients with PFP.

Methods

Subjects

This study was approved by the Non-Interventional Ethical Committee of University (26/05/2013, LUT 12/175) (ClinicalTrials.gov NCT02707679). All the patients were informed, after which they signed their written informed consent forms. Forty-one female patients at the age range of 20–45 who had been diagnosed with PFP by a specialist of orthopedics and traumatology were incorporated into the study.

Inclusion criteria were: (i) durations lasting longer than two months, (ii) pain scoring three or more according to Visual Analogue Scale (VAS) during at least two activities (prolonged sitting, ascending-descending stairs, squatting, kneeling and jumping-running), (iii) age between 20 and 45 (to reduce the risk of osteoarthritic changes in patellofemoral joint). The patients who had meniscus tear, bursitis, ligament injury, patellar tendon lesions, joint degeneration, patellofemoral dislocation and/or recurrent subluxation as well as those who had undergone lower extremity surgery were excluded. Patient with knee pain caused by the hip, lumbal spine or ankle joint were also excluded. Thirty-five female patients diagnosed with unilateral PFP were randomized into 2 groups with the help of a computer-generated randomization. The patients in the first group (n = 18) received two techniques pertaining to MWM intervention (Straight Leg-Raise with Traction and Tibial Gliding) along with an exercise therapy. In the second group (n = 17), however, KT practice and exercise therapy were performed on the patients. The patients received 4 sessions of treatment twice a week for a period of 2 weeks and were, then, followed up in accordance with a 6-week-home exercise program (Fig. 1).

Assessment parameters

All the patients were evaluated before the treatment, 45 min after the initial treatment, at the end of the 4-session-treatment during 2-week period and 6 weeks later. Age, height, body weight, body mass index (BMI), and pain durations were recorded. In order to evaluate the knee pain in the course of resting and activity (climbing up-down the stairs), the visual analogue scale (VAS) was used.[31] The Kujala Patellofemoral Scoring test which was evaluated over 100 points and which questioned pain, functional performance, limping, applying load on both of the lower extremities, walking, climbing up-down the stairs, squatting, running, jumping, sitting for a long time with bent knees, swelling, abnormal and painful patellar movement, flexion deficit and femoral atrophy was performed under the guidance of physiotherapist.[32,33]

Universal goniometer was used for evaluating the knee joint range of motion and hamstring flexibility. To evaluate the functional performances of the patients, 10-step-ascent & descent stair-climbing test and timed up&go test (TUG) were used.[15,34]

The dynamic balance measurements of the patients were evaluated through Y-Balance Test. Each measurement was repeated 3 times, after which the mean value was obtained in cm. Prior to the beginning of the test, the patient was allowed to do some practice a couple of times and then to start the test when she was ready.[35,36]

Treatment program

MWM technique

The two techniques of MWM method were performed on the patients.[22,37]

- ***Straight Leg-Raise with Traction***: The extremity on which the practice would be performed in supine position was grasped from the ankle level and was, then, subjected to traction longitudinally. Afterward, the knee was lifted up passively while in extension and was kept for waiting for a few seconds at the point where tension was felt and was, then, returned to its initial position. The practice was repeated 10 times, and 3 sets of practice at 1-min-intervals were performed (Fig. 2).
- ***Tibial Gliding***: The patients were asked, in the first place, whether or not they felt any pain in the course of the active knee flexion–extension movement while in supine position. In the patients who had pain, the treatment was started on in the position in which no load was transferred onto the knee joint. Each patient was tested in every direction in the course of the active knee flexion–extension movement so as to find out the best pain-free gliding direction (medial–lateral part of the tibia, anterior–posterior, internal–external rotation). While a hand femur was being fixated in accordance with the treatment direction selected by the therapist, the other hand was subjected to gliding towards tibia, and at that moment, the patient was asked to perform 10 repetitive active knee flexion–extension. The practice was performed by doing 10 repetitions for 3 sets and by providing 1-min-resting time between the sets. Throughout the treatment process, particular attention was paid to allowing the position of the hands, the gliding direction and force to remain the same all through the movement process.[25,37] If the patient felt no pain in supine position both during and after the practice, the position in which weight/load was conveyed was started to be performed (Fig. 3). This group of patients was also given an additional home exercise program specific to the technique and in the direction selected for the treatment (Fig. 4).

Kinesiotaping

To maintain proprioceptive stimulation in the quadriceps (from origo towards insertio) and to alleviate the tension of hamstring muscle, a 'Y'-shaped kinesiotape was applied by using the muscle technique. Afterward, 2 pieces of 'I'-shaped tapes were stretched by 75% through the mechanical correction technique and were applied around the patellar circumference in the way that it would allow the patella to move naturally in the femoral cavity while the knee was in 45° flexion (Fig. 5).

Home exercise program for both group

All the patients were provided with exercises within the scope of the home exercise program; hamstring muscle stretching (8–10 reps of 20 s hold), straight leg raise (3 sets 10 reps), bridge exercise (3 sets 10 reps), clamshell exercise for gluteus medius (3 sets 10 reps), 4-way- hip strengthening exercises with elastic bands (2 sets 10 reps), terminal knee extension with elastic band while patients were in standing position (2 sets 10 reps), and mini-squatting exercises (2 sets 10 reps). They were asked to do these exercises in 3 sets a day along with 10 repetitions for a period of 6 weeks.

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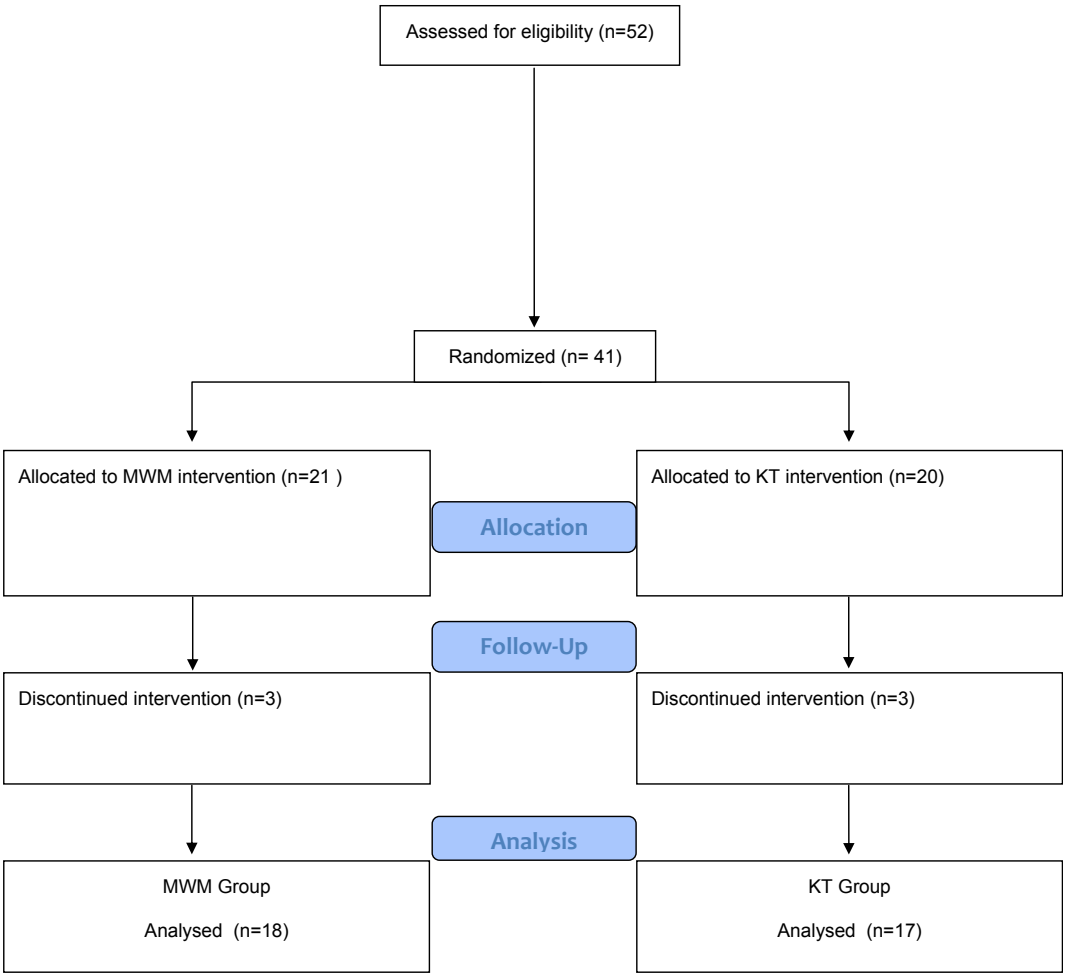

Fig. 1. Flow chart of the study process. (MWM, Mobilization with movement; KT, Kinesiotaping).

Fig. 2. Straight leg-raise with traction.

Statistical analyses

The Statistical Package for Social Sciences (version 21.0, SPSS, Chicago, IL) software was used for statistical analysis. A sample size of 15 per group was required based on 80% power. The independent variables were treatment group (MWM with exercise or KT with exercise) and time (before the treatment, 45 min after the initial treatment, at the end of the 4-session-treatment during 2-week period and 6 weeks later). Mean baseline demographic values were calculated for continuous variables. Comparisons within and between each group were assessed by a two-way repeated measures ANOVA. The statistical significance level was accepted as $p < 0.05$.

Results

When the data involving the ages, heights, body weights and body mass indexes of the patients in both groups were compared, no statistically significant difference was found between the groups ($p > 0.05$) (Table 1).

While there was a significant difference in the measurements of the pain evaluated at the time of resting ($p = 0.008$) and the hamstring muscle flexibility ($p = 0.027$) between the groups, no difference was found between the groups in terms of the pain at the time of climbing up-down the stairs, range of motion of the knee joint, 10-step- upward and downward stair-climbing, timed up&go test, Y-balance test and Kujala scores ($p > 0.05$) (Table 2).

In the intra-group evaluations, changes that occurred in the values recorded before the treatment, after the initial (1st treatment session) treatment, at the end of the 2nd week that treatment lasted and 6 weeks after the treatment in control measurements were seen to be statistically significant in all the parameters evaluated in both of the groups ($p < 0.05$) (Table 2).

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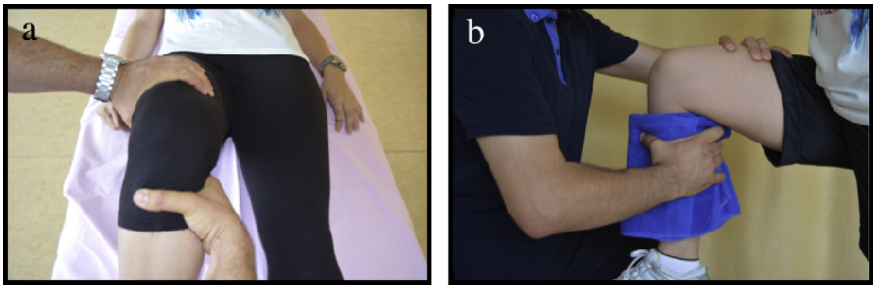

Fig. 3. **a)** MWM during active knee flexion and extension. **b)** MWM in weight bearing position.

Fig. 4. Self-applied MWM home exercise.

Fig. 5. Kinesiotaping application.

Discussion

The MWM technique and KT practices were observed to have provided recovery in all parameters. In addition, the MWM technique proved to be more effective than the KT technique in alleviating the resting pain and in enhancing the hamstring muscle flexibility in short-term measurements.

Campola et al compared the effects of 2 different taping techniques in the course of functional activities performed by 20 patients with unilateral anterior knee pain. As a result, it was found that Kinesiotaping and McConnell taping techniques had alleviated the pain at the time of climbing up the stairs.[19] Similarly, in our study, alleviation of pain during the activities like climbing up-down the stairs was obtained in all the measurements pertaining to both groups. This physiological effect might be efficient in eliminating the symptoms of pain that emerge due to muscle tensions and alignment dysfunction in patients. Additionally, the correction technique around the patellar circumference of the patients, supporting the patella in the position that it anatomically had to be also had an effect on the alleviation of the pain.

Takasaki et al, in which short-term effects of MWM technique on pain and function were examined on the patients with knee osteoarthritis (OA), a statistically significant recovery was obtained in all the measurements in terms of pain severity. The best recovery, however, was attained in the measurements performed right after the treatment.[23] Similarly, in our study, a more rapid decrease, particularly in the resting pain values, was obtained in MWM group when compared with KT group during the evaluations performed right after the initial treatment and at the end of the 2-week-treatment. This rapid recovery within the MWM group originated from the feedback of the pain-free active movement provided for the patient.

As the MWM technique lies the practice of setting by performing the pain-free movement along with the active participation of the patient, this change in the mechano-receptor perception leads to a re-organization.[23] Pain free range of motion diminishes the patient's fear of movement and enables her/him to do the

Table 1
Demographics characteristics of the subjects.

	MWM (n = 18) X ± SD	KT (n = 17) X ± SD	p
Age (years)	37.5 ± 7.8	36.7 ± 7.8	0.684
Height (cm)	162.3 ± 3.9	164.8 ± 5.1	0.108
Weight (kg)	66.8 ± 9.5	67.4 ± 14.03	0.886
Body Mass Index (BMI) (kg/m^2)	25.4 ± 3.9	24.7 ± 4.9	0.443

X: Average, SD: Standard Deviation, MWM: Mobilization With Movement, KT: Kinesiotaping.

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Table 2
Inter-group and intra-group comparisons.

	Pre-treatment		Post-treatment I		Post-treatment II		6th week		A		B		C	
	MWM (n = 18) X ± SD.	KT (n = 17) X ± SD.	MWM (n = 18) X ± SD.	KT (n = 17) X ± SD.	MWM (n = 18) X ± SD.	KT (n = 17) X ± SD.	MWM (n = 18) X ± SD.	KT (n = 17) X ± SD.	F	p	F	p	F	p
Pain														
Resting	3.5 ± 2.01	4.2 ± 1.4	1.6 ± 1.5	3.7 ± 1.4	0.6 ± 0.9	1.7 ± 1.3	0.3 ± 0.7	1 ± 1.3	8.01	**0.008**	32.835	**0.0001**	21.861	**0.0001**
Stair climbing (down)	5.8 ± 1.7	5.5 ± 1.4	3.7 ± 1.5	4.2 ± 1.2	2 ± 1.7	2.7 ± 1.9	1.5 ± 1.4	1.8 ± 1.8	0.414	0.525	42.388	**0.0001**	35.309	**0.0001**
Stair climbing (up)	5.8 ± 1.4	5.8 ± 1.5	4.2 ± 1.2	4.7 ± 1.49	2.6 ± 1.7	3.2 ± 2.02	1.9 ± 1.5	2.06 ± 1.8	0.4	0.531	45.213	**0.0001**	50.081	**0.0001**
Flexibility (°)	15.5 ± 7.4	17.06 ± 8.7	9.3 ± 6.6	16.5 ± 8.5	4.7 ± 5.2	13.7 ± 8.6	5.3 ± 7.3	10.9 ± 8.9	5.30	**0.027**	35.204	**0.0001**	21.21	**0.0001**
Knee ROM (°)	127.2 ± 5.5	127.4 ± 8.1	128.3 ± 5.2	127.4 ± 8.1	130.3 ± 4.3	129.06 ± 6.9	130.3 ± 4.35	129.7 ± 6.6	0.103	0.751	10.529	**0.001**	6.973	**0.007**
TUG (sn)	6.8 ± 0.9	6.7 ± 1.07	6.5 ± 0.8	6.5 ± 1.1	6.2 ± 0.6	6.1 ± 0.9	6.06 ± 0.4	6.1 ± 0.8	0.009	0.926	10.268	**0.001**	15.48	**0.0001**
10-Step Stair Climbing Test (s)	10.2 ± 4.2	9.5 ± 2.7	9.6 ± 3.6	8.9 ± 2.3	8.8 ± 2.6	8.01 ± 1.6	8.3 ± 2.07	7.9 ± 1.71	0.526	0.473	3.441	**0.044**	4.85	**0.016**
Y-Balance test (cm)														
Anterior	58.7 ± 5.8	58.5 ± 6.5	59.04 ± 5.2	58.9 ± 6.5	60.5 ± 5.1	60.1 ± 5.9	60.9 ± 5.1	60.8 ± 5.7	0.009	0.923	14.017	**0,0001**	9.553	**0.001**
Posteromedial	81.8 ± 7.7	82.5 ± 7.5	82.2 ± 7.5	82.9 ± 7.6	84.1 ± 6.9	83.4 ± 7.5	84.5 ± 6.7	84.3 ± 6.9	0.002	0.962	17.269	**0.0001**	8.293	**0.002**
Posterolateral	75.1 ± 8.7	76.7 ± 10.1	76.2 ± 7.7	77.1 ± 10.3	77.9 ± 7.1	78.09 ± 9.6	78.5 ± 6.8	79.02 ± 9.2	0.065	0.8	11.825	**0.0001**	8.763	**0.002**
Kujala Patellofemoral Pain Score	67.8 ± 14.01	70.8 ± 11.6	–	–	77.6 ± 12.7	77.06 ± 12.2	80 ± 11.64	79.5 ± 12.5	0.025	0.875	62.051	**0.0001**	31.068	**0.0001**

X: Average, **SD:** Standard Deviation, **MWM:** Mobilization With Movement, **KT:** Kinesiotaping, **Post-treatment I:** 45 after the initial treatment, **Post-treatment II:** End of the 4-session treatment during 2-week **A:** Comparison of the inter groups, **B:** Intra-group comparison of MWM, **C:** Intra group comparison of KT.
$p < 0.05$: Values below 0.05 were considered statistically significant.

exercises more efficiently and makes it possible for us to see the effects of the performed practice quickly. Therefore, a more prominent recovery in the resting pain during the 2-week-treatment might be no practice performed unless pain free in weight bearing position.

In addition, the rapid change in the post-treatment pain perception in both MWM and KT groups provided an increase in their functional performances. Evgniya Dimitrova et al demonstrated that MWM technique in the individuals with knee OA had alleviated pain and had been effective in enhancing the range of motion of the knee.[38] Additionally, Malgaonkar et al, investigated the short-term effects of MWM and KT on pain and function in the patients with knee OA, emphasized the fact that both of the techniques had similar effects; yet, the recovery rate of the MWM technique in intra-group analyses proved to be higher than that of KT.[39]

In literature, one of the causes of PFP is the decrease in the muscle flexibility of the lower extremity. White et al evaluated the flexibility of hamstring muscle in PFP patients, and when they compared these PFP patients with the healthy controls, they identified a shorter hamstring muscle.[40] In our study, there was recovery in MWM group by 46.1% in the measurements performed right after the initial treatment, and KT group had recovery by 2.8%, while MWM group attained recovery by 72.2% in the measurements performed at the end of the 2-week-treatment, and 23.9% recovery was observed in KT group. A more rapid increase was determined in favor of MWM group in terms of the flexibility of the hamstring muscle. This rapid increase in flexibility might stimulate the mechanoreceptors around the knee and hip, which also enhances the tensioning tolerance, and eventually, this mechanism causes a rapid increase in flexibility. Similarly, Hall et al, in which the effects of MWM technique involving straight leg-raise with traction on movement expansion in 26 healthy cases were investigated, a 27% recovery was attained in the hamstring muscle flexibility after a single practice.[27] KT is also believed to have benefit on hamstring muscle flexibility as a result of several functions like decreasing pain, correcting malaligned joints, relieving muscle spasms.[16]

In our study, while recovery was attained in the Y-balance test values in both groups, the groups had no superiority to one another. This recovery in the Y-balance test values might be improved as a result of eliminating the pain-related muscle inhibition and increase in motor control. Miller et al, investigated the acute effects of lateral gluteal KT and lumbo-pelvic manipulation on the patients with unilateral PFP, obtained a greater recovery in the joint range of motion values in Y-balance test and in squatting in the immediate measurements of KT group when they compared lumbo-pelvic and control groups.[41]

The lack of control group may be considered to be a deficiency in our study. Further studies in which imaging methods are used must be conducted so as to determine objectively whether or not these practices performed cause any positional change in the joint.

As the result of our study, it was found that the short-term effects of MWM and KT practices performed in addition to the exercises proved to be similar to one another. When the acute effects of both of these treatment methods on pain and flexibility are taken into consideration, we think that these methods are quite effective in enhancing patient motivation prior to the exercises, their participation in the treatment process and the efficiency of the exercises as well as getting patients to adopt the habit of doing exercises.

Declaration of interest

The authors declare no conflicts of interests.

References

1. Roush JR, Curtis Bay R. Prevalence of anterior knee pain in 18-35 year-old females. *Int J Sports Phys Ther*. 2012;7(4):396–401.
2. Werner S. Anterior knee pain: an update of physical therapy. *Knee Surg Sports Traumatol Arthrosc*. 2014;22(10):2286–2294.
3. Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, Beutler A. Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scand J Med Sci Sports*. 2010;20(5):725–730.
4. Fulkerson JP. Diagnosis and treatment of patients with patellofemoral pain. *Am J Sports Med*. 2002;30(3):447–456.
5. Sanchis-Alfonso V. *Anterior Knee Pain and Patellar Instability*. Springer-Verlag London Limited; 2011.
6. Warden SJ, Hinman RS, Watson MA, Avin KG, Bialocerkowski AE, Crossley KM. Patellar taping and bracing for the treatment of chronic knee pain: a systematic review and meta-analysis. *Arthritis Care Res*. 2008;59(1):73–83.
7. Crossley K, Bennell K, Green S, Cowan S, McConnell J. Physical therapy for patellofemoral pain a randomized, double-blinded, placebo-controlled trial. *Am J Sports Med*. 2002;30(6):857–865.
8. Hryvniak D, Magrum E, Wilder R. Patellofemoral pain syndrome: an update. *Curr Phys Med Rehabil Rep*. 2014;2(1):16–24.
9. Collado H, Fredericson M. Patellofemoral pain syndrome. *Clin Sports Med*. 2010;29(3):379–398.
10. Kettunen JA, Harilainen A, Sandelin J, et al. Knee arthroscopy and exercise versus exercise only for chronic patellofemoral pain syndrome: a randomized controlled trial. *BioMedCentral Med*. 2007;5(1):1–8.
11. Petersen W, Ellermann A, Gösele-Koppenburg A, et al. Patellofemoral pain syndrome. *Knee Surg Sports Traumatol Arthrosc*. 2014;22(10):2264–2274.
12. Halabchi F, Mazaheri R, Seif-Barghi T. Patellofemoral pain syndrome and modifiable intrinsic risk factors; how to assess and address? *Asian J Sports Med*. 2013;4(2):85–100.
13. LaBella C. Patellofemoral pain syndrome: evaluation and treatment. *Prim Care Clin Off Pract*. 2004;31(4):977–1003.
14. Kase K, Wallis J, Kase T. *Clinical Therapeutic Applications of the Kinesio Taping Methods*. Tokyo: Ken'i-kai information; 2003.
15. Tunay VB, Akyüz A, Önal S, et al. Patellofemoral ağrı sendromunda kinezyo ve McConnell patellar bantlama tekniklerinin performans üzerine anlık etkilerinin karşılaştırılması. *Fiz Rehabil*. 2008;19(3):104–109.
16. Akbas E, Atay AO, Yuksel I. The effects of additional kinesio taping over exercise in the treatment of patellofemoral pain syndrome. *Acta Orthop Traumatol Turc*. 2011;45(5):335–341.
17. Aminaka N, Gribble PA. A systematic review of the effects of therapeutic taping on patellofemoral pain syndrome. *J Athl Train*. 2005;40(4):341–351.
18. Aytar A, Ozunlu N, Surenkok O, Baltacı G, Oztop P, Karatas M. Initial effects of kinesio® taping in patients with patellofemoral pain syndrome: a randomized, double-blind study. *Isokinet Exerc Sci*. 2011;19(2):135–142.
19. Campolo M, Babu J, Dmochowska K, Scariah S, Varughese J. A comparison of two taping techniques (kinesio and mcconnell) and their effect on anterior knee pain during functional activities. *Int J Sports Phys Ther*. 2013;8(2):105–110.
20. Kuru T, Yaliman A, Dereli EE. Comparison of efficiency of Kinesio® taping and electrical stimulation in patients with patellofemoral pain syndrome. *Acta Orthop Traumatol Turc*. 2012;46(5):385–392.
21. Wilson E. The Mulligan concept: NAGS, SNAGS and mobilizations with movement. *J Bodyw Mov Ther*. 2001;5(2):81–89.
22. Mulligan BR. Manual Therapy: "nags", "snags", "mwms" Etc. In: 5th ed. New Zealand: Plane View Services Ltd; 2004.
23. Takasaki H, Hall T, Jull G. Immediate and short-term effects of Mulligan's mobilization with movement on knee pain and disability associated with knee osteoarthritis-A prospective case series. *Physiother Theory Pract*. 2013;29(2):87–95.
24. Vicenzino B, Paungmali A, Teys P. Mulligan's mobilization-with-movement, positional faults and pain relief: current concepts from a critical review of literature. *Man Ther*. 2007;12(2):98–108.
25. Teys P, Bisset L, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on range of movement and pressure pain threshold in pain-limited shoulders. *Man Ther*. 2008;13(1):37–42.
26. Gopal Nambi S, Shah BT. Kinesio taping versus Mulligan's mobilization with movement in sub-acute lateral ankle sprain in secondary school Hockey players-comparative study. *Int J Pharm Sci Health Care*. 2012;2(2):136–149.
27. Hall T, Cacho A, McNee C, Riches J, Walsh J. Effects of the Mulligan traction straight leg raise technique on range of movement. *J Man Manip Ther*. 2001;9(3):128–133.
28. Djordjevic OC, Vukicevic D, Katunac L, Jovic S. Mobilization with movement and kinesiotaping compared with a supervised exercise program for painful shoulder: results of a clinical trial. *J Manip Physiol Ther*. 2012;35(6):454–463.
29. Collins N, Teys P, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains. *Man Ther*. 2004;9(2):77–82.
30. Beselga C, Neto F, Alburquerque-Sendín F, Hall T, Oliveira-Campelo N. Immediate effects of hip mobilization with movement in patients with hip osteoarthritis: a randomised controlled trial. *Man Ther*. 2016;22(4):80–85.
31. Crossley KM, Bennell KL, Cowan SM, Green S. Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? *Arch Phys Med Rehabil*. 2004;85(5):815–822.
32. Kuru T, Dereli EE, Yaliman A. Validity of the Turkish version of the Kujala patellofemoral score in patellofemoral pain syndrome. *Acta Orthop Traumatol Turc*. 2004;44(2):152–156.
33. Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, Nelimarkka O. Scoring of patellofemoral disorders. *Arthrosc J Arthrosc Relat Surg*. 1993;9(2):159–163.
34. Wall JC, Bell C, Campbell S, Davis J. The timed get-up-and-go test revisited: measurement of the component tasks. *J Rehabil Res Dev*. 2000;37(1):109–113.
35. Kinzey SJ, Armstrong CW. The reliability of the star-excursion test in assessing dynamic balance. *J Orthop Sports Phys Ther*. 1998;27(5):356–360.
36. Gribble PA, Hertel J. Considerations for normalizing measures of the star excursion balance test. *Meas Phys Educ Exerc Sci*. 2003;7(2):89–100.
37. Mulligan B. *NAGS, SNAGS, MWM etc*. 6th ed. Wellington, New Zealand: Plane View Services Ltd.; 2006.
38. Dimitrova E. Efficacy of mobilizations with movement in patients with knee osteoarthritis. *Sport Med J*. 2008;16(4):16.
39. Malgaonkar PP, Sai Kumar N, Vinod Babu K, Rizvi SR. Short term effect of Mulligan's mobilization versus Kinesio Taping on knee pain and disability for osteoarthritis of knee. *Int J Physiother*. 2014;1(4):233–240.
40. White LC, Dolphin P, Dixon J. Hamstring length in patellofemoral pain syndrome. *Physiotherapy*. 2009;95(1):24–28.
41. Miller J, Westrick R, Diebal A, Marks C, Gerber JP. Immediate effects of lumbopelvic manipulation and lateral gluteal Kinesio Taping on unilateral patellofemoral pain syndrome a pilot study. *Sports Health A Multidiscip Approach*. 2013;5(3):214–219.

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